

# Radar Sounding and Propagation through Heterogeneous Media

Completed Technology Project (2015 - 2017)



## Project Introduction

This project is developing a radar sounder raw data simulator tool to predict radar echoes from large, heterogeneous dielectric subsurface domains for terrestrial and planetary radar sounders to aid instrument development and science interpretation of measured radargrams.

The radar sounder raw data simulator tool we are developing is composed of two computational modules designed to address different regimes of the sounding scattering problem: the Pseudo-Spectral Time-Domain (PSTD) for scattering from shallow subsurface dielectric heterogeneities, and the Multi-layer Fast Multipole Method (FMM) for scattering from deep, large-scale dielectric interfaces. In addition there are modules for radar wave propagation through dense heterogeneous atmospheres. The tool has been designed to be parallelized on the AmazonGov. This is enabling technology to allow broad-based system engineering for the design of planetary and terrestrial radar sounders, the development of subsurface SAR algorithms, and validating/refining observable signatures of scientific hypotheses.

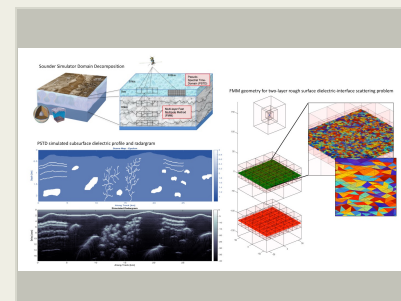
## Anticipated Benefits

This tool will address a gap in simulation capability for existing, proposed, and future potential planetary and terrestrial sounder missions for Mars, Venus, Earth (e.g., atmosphere, ice sheets), Europa, Ganymede, Enceladus or other icy planetary bodies. It will be a critical tool in developing radar sounders with immediate applicability to existing planetary sounders, e.g., REASON (NASA, planned Europa-Clipper), RIME (ESA-JUICE, JPL partner), in addition MARSIS and SHARAD data analysis.

Potential future missions to which this tool can be applied are: NASA-ARM (Asteroid Redirect Mission) interior sounding, VERITAS (proposed Venus radar mission) atmospheric propagation effects, DesertSea (airborne sounder, instrument development and data analysis). In addition, the tool can aid the development and analysis of shallow subsurface GPR (ground penetrating radar) for rover radars, shallow ice and water detection (Mars), and mapping small icy-body interiors.

This simulation tool can be applied to radar sounding of small icy-bodies and interior mapping, with applications to commercial space mining.

This tool and the methods developed apply to all NSF funded terrestrial airborne Arctic and Antarctic radar sounder science and data analysis. In addition, the tool applies to DoD subsurface radar applications (e.g., GPR for UXO detection).



Project Image Radar sounder raw data simulator domain decomposition and simulated radargram for the Pseudo-Spectral Time-Domain (PSTD) and Multi-layer Fast Multipole Method (FMM) computational modules.

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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Jet Propulsion Laboratory (JPL)	Lead Organization	NASA Center	Pasadena, California

Co-Funding Partners	Type	Location
Stanford University (Department of Geophysics)	Academia	Stanford, California

Primary U.S. Work Locations
California

## Organizational Responsibility

**Responsible Mission Directorate:**

Mission Support Directorate (MSD)

**Lead Center / Facility:**

Jet Propulsion Laboratory (JPL)

**Responsible Program:**

Center Independent Research &amp; Development: JPL IRAD

## Project Management

**Program Manager:**

Fred Y Hadaegh

**Project Manager:**

Fred Y Hadaegh

**Principal Investigator:**

Mark S Haynes

**Co-Investigators:**

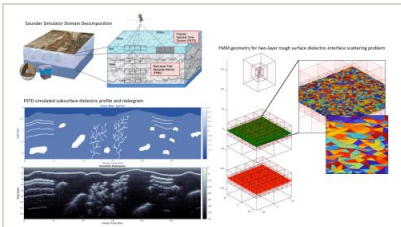
Darmindra D Arumugam  
 Thomas A Cwik  
 Xueyang Duan  
 Scott Hensley  
 Joseph McMichael  
 Jeffrey J Plaut  
 Dustin M Schroeder  
 Helene Seroussi

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## Images



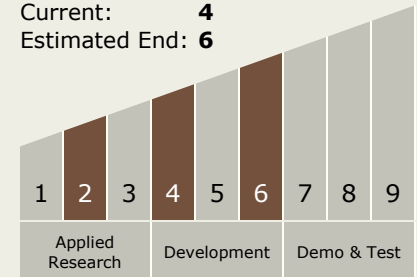
### Radar Sounding and Propagation through Heterogeneous Media Project Image

Project Image Radar sounder raw data simulator domain decomposition and simulated radargram for the Pseudo-Spectral Time-Domain (PSTD) and Multi-layer Fast Multipole Method (FMM) computational modules.

(<https://techport.nasa.gov/image/26089>)

### Technology Maturity (TRL)

Start: **2**  
Current: **4**  
Estimated End: **6**



### Technology Areas

#### Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - └ TX11.5 Mission Architecture, Systems Analysis and Concept Development
  - └ TX11.5.2 Tools and Methodologies for Performing Systems Analysis